CONTINUED USE OF PCB-CONTAMINATED CONCRETE THROUGH IMPLEMENTATION OF THE 40 CFR 761.30(p) USE AUTHORIZATION

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The 40 CFR 761.30(p) use authorization for PCB-contaminated porous surfaces was applied to concrete floors at an electric utility's transformer shop and PCB storage building. This authorization allows PCB-contaminated concrete to be managed in place while it remains in service, provided that it is surface washed, encapsulated, and marked to indicate the presence of PCBs that will ultimately need to be disposed of. Experiences gained from the implementation of this process for continued-use are presented.

INTRODUCTION

The U. S. Environmental Protection Agency (USEPA) Toxic Substance Control Act (TSCA) polychlorinated biphenyl (PCB) regulations promulgated in 40 CFR 761 on 28 June 1998 authorize the "continued use of porous surfaces contaminated with PCBs regulated for disposal by spills of liquid PCBs." This authorization, found in 761.30(p), allows PCB-contaminated porous surfaces to be managed in-place for the remaining useful life of the surface provided that the conditions specified in the regulations are met. The authorization is intended for materials such as concrete where PCB concentrations equal to or exceeding 50 mg/kg have been spilled. Concrete affected by less-than-72-hour-old spills of 50 mg/kg or more PCBs may be decontaminated by solvent washing in accordance with 761.79(b)(4), but concrete affected by older spills cannot be decontaminated and is regulated for disposal. The 761.30(p) continued-use authorization provides a short-term alternative to concrete removal and disposal.

The 761.30(p) continued-use authorization was used to address approximately 7,000 square feet of PCB-affected concrete floors at an electric utility's transformer shop and PCB storage building in 1999. This paper describes the activities performed to comply with the continued-use authorization, the schedule and cost requirements for the work, lessons learned during the project, and some of the limitations to this approach of managing PCB-affected concrete in place.

METHOD

The 40 CFR 761.30(p) continued-use authorization for porous surfaces allows PCB-contaminated concrete to be managed in place provided that several conditions are met. The requirements are specified in 761.30(p)(1) through 761.30(p)(4) and include removing the PCB source, washing the surface using the 40 CFR 761 Subpart S double-wash-rinse procedure, encapsulating with two layers of epoxy or a solid surface, and marking to identify the continuing presence of PCBs. These steps, as well as several other activities not directly specified by the regulations, were performed to address the PCB-contaminated concrete floors located at a transformer shop and PCB storage building under the continued-use authorization for porous surfaces.

Initial Investigation

The locations of historical transformer oil spills, the PCB concentrations in those spills, and the concentrations of PCBs in the affected concrete floors were unknown at the start of the project. It was known, however, that electrical transformers had been stored and serviced in the buildings. Investigation activities were performed to determine the extent of PCBs in the concrete, if any, and evaluate what further actions needed to be taken. Facility personnel were interviewed to determine the location of historical transformer storage and servicing activities. Sampling activities then were performed to determine the presence of PCBs at these locations. The sampling focused on the collection of data needed to identify the presence of PCBs in the concrete floors and obtain information that could be used to evaluate the applicability of the 761.30(p) continued-use authorization for PCB-affected porous surfaces.

The concrete floors initially were characterized by collecting wipe samples on a 3-meter square grid. Each wipe sample was collected by rubbing a clean gauze pad soaked in 3 mL of hexane over a 10-centimeter-(cm)-by-10-cm square area. Wipe sampling was performed because the original form of the PCB Disposal Amendments Final Rule published in the 28 June 1998 Federal Register indicated that the 761.30(p) continued-use authorization was intended for "surfaces contaminated by spills of liquid PCBs at a concentration exceeding 10 μg/100 cm^2," which is a surface standard. Comparison to the 10 μg/100 cm^2 standard required that wipe sampling of the concrete floor surface be performed. The wipe samples were analyzed for PCBs using USEPA SW-846 Method 8082, and the results revealed PCBs as high as 66.2 μg/100 cm^2 in areas where electrical equipment had been handled.

Bulk concrete samples also were collected from the concrete floors because the 40 CFR 761.61 disposal regulations and 761 Subpart N sampling procedures for porous materials indicate that bulk sampling is a more appropriate means of characterizing PCB-affected concrete for disposal. Bulk sampling was performed on a 3-meter grid by drilling core samples into the concrete and collecting concrete chips and dust from the upper 1-inch of the concrete floor. The sample analytical results revealed PCB concentrations as high as 1,390 mg/kg in the concrete floor, with the elevated PCB concentrations found in bulk samples generally occurring where elevated PCBs had been found in surface wipe samples.

Both the wipe and bulk sample results were used to identify areas of PCB-contaminated concrete that either needed to be removed for disposal or addressed under the 761.30(p) continued use authorization. These areas were identified as concrete floors having PCB concentrations that exceeded the 10 μg/100 cm^2 criteria indicated in the original form of 761.30(p) and the 761.61(a) self-implementing porous media cleanup criteria of 1 mg/kg for high-occupancy work areas (transformer shop) and 25 mg/kg for low-occupancy work areas (PCB storage building). To be conservative, it was assumed that concrete with PCB concentrations exceeding either the wipe or bulk standards needed be addressed using the 761.30(p) continued-use authorization so that the concrete could continue to be managed in place. It should be noted however, that the final version of the 761.30(p) that appears in 1999 edition of 40 CFR has been revised to indicate that the continued-use authorization applies to concrete where spills containing 50 mg/kg or more PCBs, instead of the previously published 10 μg/100 cm^2, have occurred. Therefore, wipe sampling and comparison to the 10 μg/100 cm^2 standard is not necessarily required or recommended.

PCB Source Control

The electric utility decided to implement the 761.30(p) continued use authorization in the areas where PCB-contaminated concrete had been identified. The first step of this procedure, found in 761.30(p)(1), required the removal of the source causing the release of PCBs. The source of PCBs at the transformer shop and PCB storage building had been leaking oil-filled electrical transformers that had historically been serviced and stored in the affected areas. This equipment was gone by the time this project was performed. However, newer transformers and other equipment were present in some of the work areas. This equipment was removed so that the subsequent steps of the continued-use authorization could be implemented.

Subpart S Double-Wash-Rinse Procedure

The double-wash-rinse procedure described in 40 CFR 761 Subpart S was performed on the PCB-contaminated concrete floors in the PCB storage building and transformer shop. This procedure is intended for the decontamination of non-porous surfaces, but 761.30(p) requires that this method be used to prepare PCB-contaminated concrete for encapsulation. Subpart S provides two double-wash-rinse approaches. The first approach (761.372) is intended for clean surfaces free of grime and involves a double solvent wash-rinse. The second approach (761.375) is intended for dirty grease- and grime-coated surfaces and involves a detergent wash-rinse followed by a solvent wash-rinse. The second approach was applied during this project by following the step-by-step instructions described in 761.375. The surface washing steps performed included a 1) detergent wash, 2) potable water rinse, 3) solvent wash, and 4) solvent rinse, which are described as follows.

Step 1 - Water/Detergent Wash: The concrete floors were washed using potable water mixed in a 1:3 ratio with *Z-Green®*, an industrial-strength detergent distributed by the ZEP Chemical Corporation. The water-detergent solution was applied so that the floor was wet, then each square foot of the floor was thoroughly scrubbed with brushes for at least 1 minute. Each square foot of the floor was then wiped for at least 1 minute using a detergent solution-soaked pad. The excess water and detergent then were collected with a vacuum and the floor was allowed to dry. This step was repeated in some areas to remove embedded grime that was not removed during the initial wash.

Step 2 - Potable Water Rinse: The floor was rinsed with potable water to remove residuals left from the initial wash. Each square foot of the floor was flushed with approximately 1 gallon of water. Absorbent pads were used to wipe the floor clean, and excess water was collected using a vacuum. The floors then were allowed to dry.

Step 3 - Solvent Wash: The second cycle of the double-wash-rinse procedure was initiated by washing the concrete floor with a solvent. The concrete floors were washed using *Big Orange® Industrial Degreaser Solvent*, a terpene-hydrocarbon product distributed by the ZEP Chemical Company. The 40 CFR 761 regulations indicate that kerosene, diesel, and terpene hydrocarbons may be used for the wash solvent. A terpene solvent was selected based on the regulatory provisions and a study by Woodyard, et. al. (1995) that found terpene hydrocarbons to be among the best solvents for decontaminating PCBs from surfaces. According to the 40 CFR 761 rules, any solvent in which PCBs are 5 percent or more soluble is acceptable. The solvent was evenly applied to the concrete floor surface. Each square foot of the floor received approximately 0.1 gallon of the solvent and was allowed to be wet for at least 1 minute. Each square foot of the floor then was wiped with solvent-soaked pads for at least 1 minute. Excess solvent was collected with clean absorbent pads and the floor was allowed to dry.

Step 4 - Solvent Rinse: The concrete floor was flushed with clean (i.e., unspent) solvent. Approximately 0.1 gallons of solvent were applied to each square foot of the floor, allowing the floor to be wet for at least one minute. The solvent was wiped on the floor using absorbent pads. Clean absorbent pads then were used to wipe the floor dry.

Additional Surface Preparation

Following completion of the double-wash-rinse procedure, a Sherwin Williams Company industrial coatings specialist was asked to inspect the cleaned concrete floor and identify an appropriate epoxy product that could be used for encapsulation. The industrial coatings specialist observed that the floor was very smooth and recommended that additional surface preparation activities be performed to increase the profile (i.e., roughness) of the concrete surface to ensure epoxy adherence to the floor.

Additional surface preparation activities were performed after the double-wash-rinse procedure to improve the profile of the concrete surface. A 30-percent muratic acid solution was applied to the concrete floor surface in all areas where the double-wash-rinse procedure had been performed. The floor was scrubbed with the muratic acid solution, which interacted chemically with the carbonate matrix of the concrete surface causing it to become slightly rougher. Spent acid solution was collected using absorbent pads. The floor was then washed with potable water to neutralize any remaining acid to ensure it did not interfere with epoxy adherence.

Encapsulation

Following the surface washing activities, an epoxy encapsulant was placed on the concrete surface according to the requirements of 761.30(p)(1)(A). The intent of the encapsulant was to prevent human contact with any PCBs that remain in the underlying concrete after completion of the double-wash-rinse procedure. This work was initiated after the concrete floor had been allowed to dry for at least 24 hours and no wet areas were apparent.

The Sherwin Williams Company was consulted to identify an epoxy encapsulant that would meet the 761.30(p) requirements. Armorseal 700 HS®, a high solids water-based epoxy manufactured by the Sherwin Williams Company, was selected. Armorseal 700 HS® is a solvent-resistant, water-repellant epoxy designed to form an extremely hard, scuff-resistant surface on concrete and metal.

Two coats of the epoxy were applied to the floor surface. The first (i.e., base) coat was red in color and was applied to the entire floor area that had been washed using the Subpart S procedure. A second (i.e., top) coat was gray in color and was applied on top of the base coat after it had been allowed to dry for at least 24 hours. The two contrasting colors were used so that any wearing of the top coat can be detected. Approximately 67 gallons of the red base coat and 58 gallons of the gray top coat were required to cover the 7,000 square feet of floor surface addressed during this project. On average, one gallon of epoxy was needed for each 113 square feet of concrete floor per coat.

A penetrating primer also was used in some areas to help seal the concrete surface before epoxy application. This primer helped to improve the uniform appearance of the subsequent epoxy coats and reduce pinhole formation seen in some areas.

Marking

Once the epoxy had dried, labels were placed on the encapsulated floor surfaces to indicate that PCBs remain in the underlying concrete, as specified under 40 CFR 761.30(p)(2)(B) of the continued-use authorization. Each area of concrete floor that had received the double-wash-rinse procedure and epoxy was marked using the USEPA PCB "M_L" label that is described in 40 CFR 761.45. The labels were applied at the entrance, corners, and central portions of each area so that they are visible to workers.

RESULTS

Surface Washing Results

Performance of the 40 CFR 761 Subpart S double-wash-rinse procedure resulted in very clean-looking concrete floors. The concrete was visibly cleaner in all locations than it was prior to the performance of the method. Practically all visible dirt, grease, and grime were removed from the floor surface once the Subpart S double-wash-rinse procedure was performed. Overall, it appeared that the floor condition complied with the intent of Subpart S double-wash-rinse procedure.

The 761.30(p) continued-use authorization does not require sampling to evaluate the presence of PCBs on the concrete surface once the double-wash-rinse is performed. However, post-wash wipe and bulk sampling was performed on this project to assess the effectiveness of the double-wash-rinse procedure in reducing PCB concentrations on the floor and to quantify the potential future liability. The numerical results for this work are confidential, but it is possible to report that PCB concentrations on the concrete surface generally decreased during the detergent wash and water rinse steps which remove oily grime from the surface, while remaining the same or slightly increasing during the solvent wash and rinse steps that may remobilize PCBs to the surface from shallow depth in the concrete.

Encapsulation Results

The Sherwin Williams Company's Armorseal 700 HS® product provided a very hard epoxy coating on the PCB-affected floor areas that effectively minimizes worker contact with the PCBs that remain in the underlying concrete. The epoxy is largely impermeable and also will prevent future spills from entering the concrete before they can be cleaned up. The epoxy also has been hard enough to withstand heavy forklift traffic and the staging of heavy equipment without cracking.

Cracks, bubbles, soft spots, and small pinholes were encountered in the epoxy at some locations immediately following its installation. The cracks and soft spots were attributable to inadequate mixing of the epoxy product with the activator chemical that causes the epoxy to harden. This mixing problem was also attributed to the contractor scraping every last bit of epoxy from the can, like one would do if they were painting. With epoxy, the product at the edges may not be exposed to the activator and should not be used. Small (<1 mm) pin holes also occurred in some places either due to concrete off-gassing or the loss of small amounts of the epoxy into the concrete matrix. The bubbles formed when moisture escaped from the concrete and built up beneath the epoxy. This would occur when there would be precipitation followed by hot temperatures. The bubbles formed overnight once temperatures cooled. The cracks, bubbles, and soft spots were repaired by grinding down the area and replacing the gray epoxy topcoat. The pinholes were repaired by filling the holes with a Sherman Williams high-strength polymer product and applying additional epoxy.

Wastes Generated

Wastes generated during the double-wash-rinse procedure and subsequent encapsulation included water mixed with detergent, water mixed with spent solvent, used absorbent materials and other equipment. These wastes were managed during the project according to applicable waste classification and disposal regulations.

Approximately 7,300 gallons of water containing PCBs were generated during the water-wash and water-rinse steps. This material was collected using hydrovacuum equipment and stored in a storage tank until the end of the project, at which time it was disposed of as a TSCA waste.

Approximately 300 gallons of spent solvent and acid solutions mixed with PCBs were generated during the solvent-washing, solvent-rinsing, and acid washing steps. These wastes were contained as specified by the U. S. Department of Transportation (DOT) hazardous materials regulations and stored indoors within fireproof cabinets until they could be transported off-site. These liquids were RCRA hazardous and were disposed of by incineration.

Wastes generated during the work also included approximately 30 drums of expendable materials that came into contact with the PCB-affected concrete and cleaning solutions. These materials included brushes, absorbent pads, epoxy paint applicators, buckets, rags, and personal protective equipment. These wastes were managed in 55-gallon drums and disposed of at a TSCA facility.

SCHEDULE REQUIREMENT

This project required approximately 11 months to complete. The first phase of the project, which involved characterization sampling, reporting, evaluation of the data, and development of contractor specifications was performed from October 1998 through February 1999. The second phase of work, involving the double-wash-rinse procedure and encapsulation, was performed in March 1999 through August 1999.

The number of days that the contractor spent performing any specific task is difficult to estimate because of the multitasking performed during the work. In some cases, the contractor was able to sequence work so that different steps of the double-wash-rinse procedure could be performed on different portions of the floor in the same day. However, an average work pace can be determined from the total amount of time the contractor spent on the project, which is as follows:

Project manager	125 hours
Field supervisor	670 hours
Total for field technicians	2,301 hours
Admin staff	150 hours

The above labor hours represents the amount of time required by the contractor to procure materials, implement the double-wash-rinse procedure, apply the epoxy, and load wastes for disposal. It also includes approximately 6 days of effort required to address problems with the initial epoxy application. Assuming that the field supervision labor represents the actual duration of field-related activities, approximately 670 hours or 67 10-hour working days were required to complete the project. The work would have been completed in approximately 61 working days at a pace of 115 square feet of floor per day if the repair of epoxy had not been needed in some areas. This repair effort represented approximately 10 percent of the entire project.

COST REQUIREMENT

The performance of the Subpart S double-wash-rinse and encapsulation activities for this project cost approximately $166,270, or $23.75 per square foot of floor area addressed. This cost included the following major items:

Project management labor	$14,330
Field supervision labor	$41,880
Field technician labor	$71,850
Administrative labor	$2,880
Surface washing equipment	$3,840
Detergent, solvent, and acid	$4,420
Epoxy encapsulant	$8,020
Safety equipment and supplies	$14,100
Field vehicles	$3,120
Flammable materials cabinets	$1,830
Subtotal	$166,270

The transportation and disposal of wastes generated during the double-wash-rinse and encapsulation activities cost approximately $47,940, or $6.85 per square foot of floor area addressed. This cost included the following items:

Disposal of solvent/acid waste	$2,100
Disposal of water with PCBs	$29,600
Disposal of PCB-containing debris	$5,880
Waste transportation	$4,060
Vacuum box rental	$6,300
Subtotal	$47,940

The engineering oversight and analytical costs for this project were approximately $39,000. This cost included effort for characterization sampling, periodic oversight of the surface washing and encapsulation activities, post-washing sample collection, and report preparation, as follows:

Initial sampling and reporting	$7,800
Contractor specifications	$8,200
Periodic oversight and sampling	$8,200
Final report preparation	$4,000
Laboratory analyses	$10,800
Subtotal	$39,000

The total project cost required to address 7,000 square feet of PCB-contaminated floor surface using the 40 CFR 761.30(p) use authorization was approximately $253,210. This amounts to approximately $36.20 per square foot of floor area when the cost for the initial investigation activities, all surface washing and encapsulation work, waste transportation and disposal, engineering oversight, post-wash sampling, final report preparation, and project management are included. Excluding engineering oversight and sampling costs, the unit rate achieved for the contractor's work and waste disposal was approximately $30.60 per square foot.

By comparison the cost to remove 7,000 square feet of PCB-contaminated concrete for disposal and replace the floor (6-inch slab) would have been on the order of $230,000, or approximately $33.00 per square foot. Excluding engineering oversight and sampling, the cost would be approximately $28 per square foot. This assumes that the entire 6-inch concrete floor slab would be removed by hazardous-waste-operations-trained workers using respiratory protection and is based on the following estimated costs:

Initial investigation and reporting	$7,200
Contractor specifications	$8,200
Concrete removal ($12.50/ft^2)	$87,500
TSCA waste disposal ($150/ton)	$39,000
Floor restoration ($3.00/ft^2)	$21,000
Engineering oversight/sampling	$30,000
Laboratory analyses	$20,100
Final report preparation	$10,000
Total	$230,000

These estimated costs for removal and restoration are for rough comparison only. This estimate assumes that additional sampling will be needed to characterize soil beneath the slab once the concrete is removed. The costs for constructing an entirely new facility also might need to be considered in addition to concrete removal and restoration, depending on the extent of the PCBs.

LESSONS LEARNED

The 40 CFR 761.30(p) use authorization and 761 Subpart S double-wash-rinse procedure had been recently published in the Federal Register at the time this project was implemented. Some lessons learned about the implementation of these procedures are summarized as follows:

- The time requirement to implement the double-wash-rinse procedure should not be underestimated. The 761 Subpart S double-wash-rinse procedure requires washing to be performed for specific amounts of time, which can be very time consuming when addressing large areas of concrete. The 104 square-feet-per-day rate achieved during this project is believed to be reasonable but somewhat slow.

- A lump sum contract should be established to place the burden of labor-, materials-, and schedule-management on the contractor so that the project does not take longer or use more materials than are necessary. However, engineering oversight should be performed to confirm that regulatory requirements are met.

- Worker safety for the contractor and surrounding facility employees needs to be considered when selecting and using the solvent. Respiratory protection should be provided to the workers performing the double-wash-rinse procedure. Additional ventilation to prevent vapors from affecting adjacent work locations should be considered.

- Surface preparation with muratic acid may be needed to increase the profile (i.e., roughness) of the concrete floor surface so that the epoxy will properly adhere to it.

- A penetrating primer should be used to help seal the concrete surface before applying the epoxy. This will result in a more uniform build and appearance of the epoxy surface and reduce the potential for materials to subside into the concrete matrix, resulting in pinholes.

- Compliance with the manufacturer's epoxy mixing instructions is critical. Failure to follow the manufacturer's instructions when mixing the activator compound in the epoxy can cause a reduction in epoxy strength and result in undesirable soft spots and cracking. The epoxy application also needs to be performed under optimum environmental conditions (dry with stable temperatures) to get the best results. Precipitation and large variations in temperature and humidity can affect the epoxy hardening process.

- Anti-slip materials may need to be included as part of the epoxy topcoat or placed on top of the final epoxy surface to reduce the slip hazard created by the smooth epoxy finish.

- Additional washing steps beyond those required by the 761 Subpart S procedure may need to be considered if a reduction of PCB concentrations to < 10 µg/100 cm^2 on the concrete surface is desired, although this is not required by the rule.

- Bulk sampling to characterize the concrete for disposal should be considered before the epoxy encapsulant is applied. This data will be needed in the future to characterize the concrete for disposal. It will not be possible to get this data later without damaging the epoxy.

LIMITATIONS

40 CFR 761.30(p) provides a good method for managing PCB-contaminated concrete surfaces in place, allowing continued use of the concrete for its remaining useful life as long as the epoxy encapsulant is maintained in good condition. This provides an alternative to the immediate disposal of concrete once it is found to be PCB-contaminated. The limitations associated with this approach should be considered however.

The primary limitation with the 761.30(p) continued-use authorization is that it does not alleviate responsibility for future disposal of the PCBs that remain "in use" in the concrete after surface washing and encapsulation activities are completed. The regulations in 761.79 imply that the concrete affected by historical PCB spills cannot be "decontaminated" using the Subpart S double-wash-rinse procedure, and it must be assumed that PCBs remain at depth in the concrete even after the surface washing activities are performed. The remaining PCBs ultimately will need to be disposed of according to the disposal regulations in 761.61 at the end of the concrete's useful life. Therefore, the continued-use authorization should be viewed as an interim action, not a long-term solution.

The use of PCB-affected concrete managed under 761.30(p) also may be limited. Although such limitations are not clearly specified in the regulations, the USEPA has stated that their intent is to allow use of the 761.30(p) authorization where the concrete will be maintained in service for its original or same use, not where the concrete will be reused for some other function or sold as part of a real estate transaction. The basis for this limitation is related to discouraging the continued presence of PCBs and the prohibitions against the distribution of PCBs in commerce found in 761.2.

The cost and time required to implement the 761.30(p) continued-use authorization may be another limitation, depending on the size of the project. The continued-use authorization may be a cost-effective means to address a large area of PCB-contaminated concrete that cannot be removed without seriously disrupting facility operations. For small areas however, it may be less expensive to remove and replace the concrete.

Long-term management of the PCB-affected concrete is needed. This requires the training of workers to inspect the encapsulant for wear and damage, procedures for repairing the encapsulant as needed, and a safety plan for workers if they need to penetrate the encapsulant and drill into the concrete for some reason. A plan for addressing the PCB remaining beneath the encapsulant when the building is sold, adapted for another use, or demolished is also needed.

Finally, implementation of the 761.30(p) continued-use authorization for concrete would not alleviate responsibility for addressing any contaminated soil that is under a PCB-contaminated concrete slab. The 761.30(p) use authorization is intended only to allow porous surfaces such as concrete to remain in service. Contaminated soil would need to be addressed according to the bulk PCB remediation waste rules found in 40 CFR 761.61.

CONCLUSIONS

The 40 CFR 761.30(p) continued-use authorization for PCB-contaminated porous surfaces was implemented for 7,000 square feet of concrete floor at a cost of approximately $253,210, or $36.20 per square foot including all field activities, engineering oversight, and waste disposal. This authorization allows the continued-use of PCB-contaminated concrete provided that PCB source removal, solvent washing of the concrete surface, encapsulation, and marking are performed. However, long-term maintenance and future disposal responsibility are associated with this approach.

REFERENCES

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